CHALLENGES OF DIGITIZING THE ENERGY SYSTEM

ERICSSON

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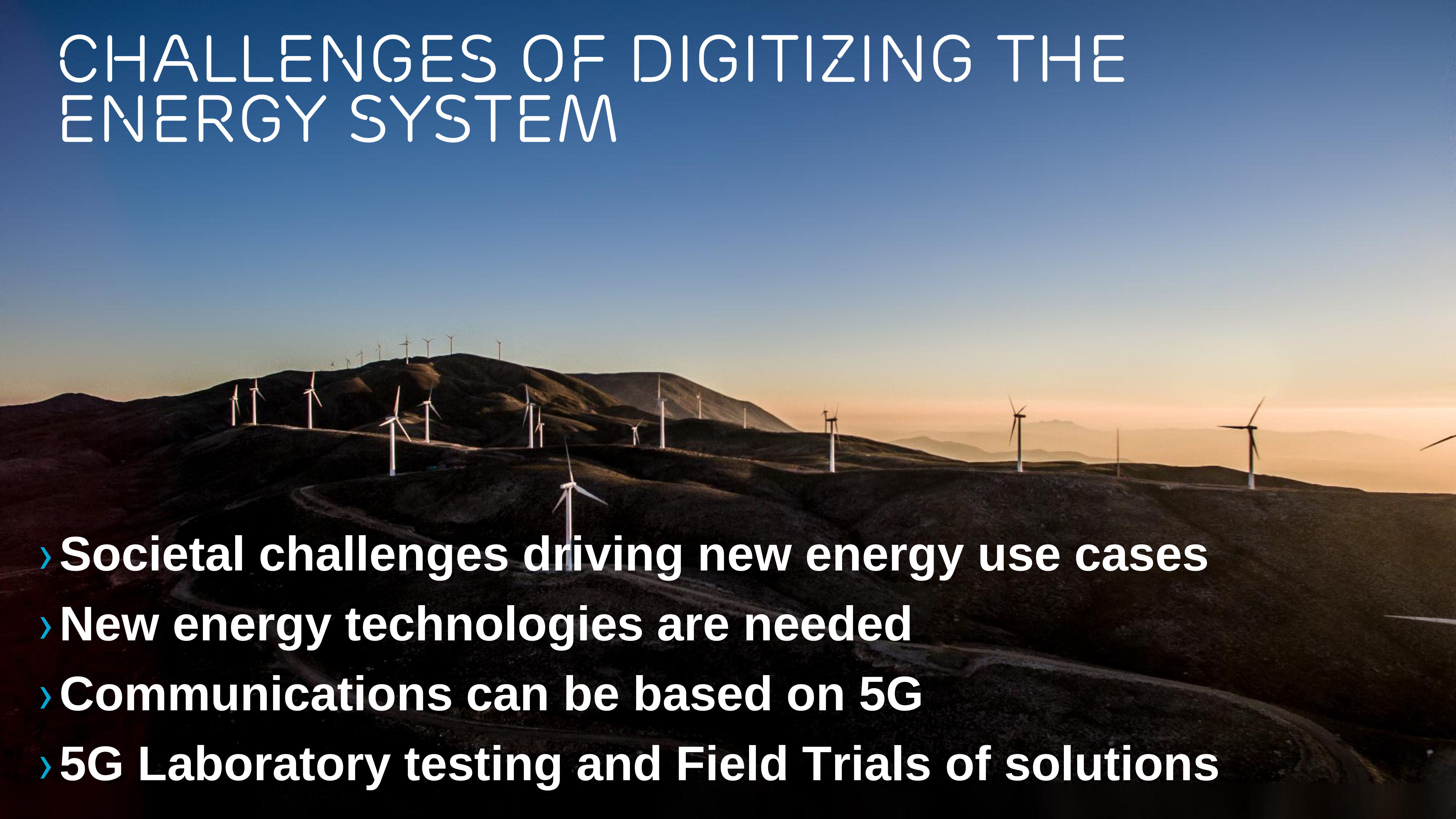
Die Energiewende – smart und digital

FVEE-Jahrestagung 2018

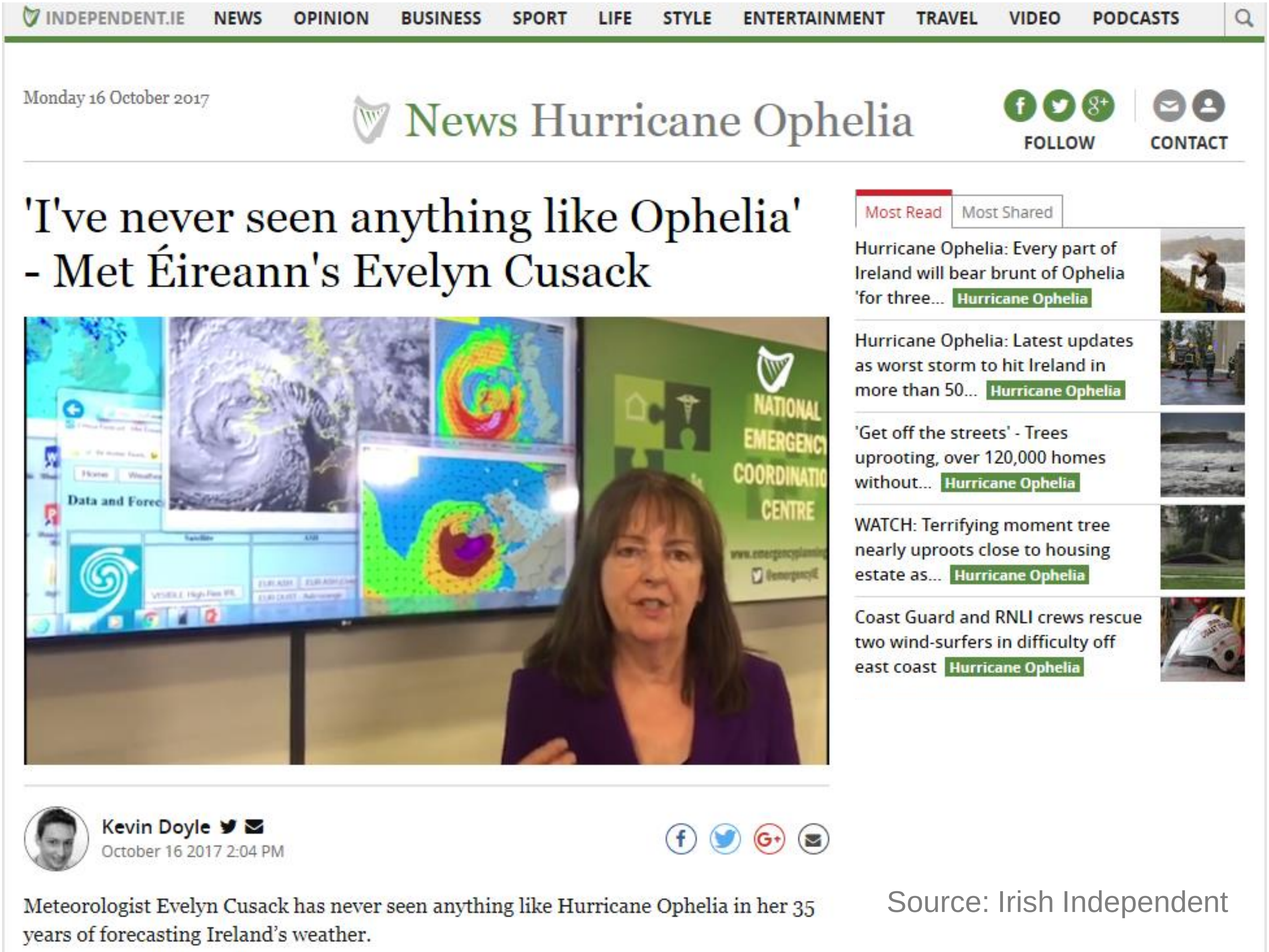


CHALLENGES OF DIGITIZING THE ENERGY SYSTEM

- Societal challenges driving new energy use cases
- New energy technologies are needed
- Communications can be based on 5G
- 5G Laboratory testing and Field Trials of solutions

HURRICANE OPHELIA HITS IRELAND

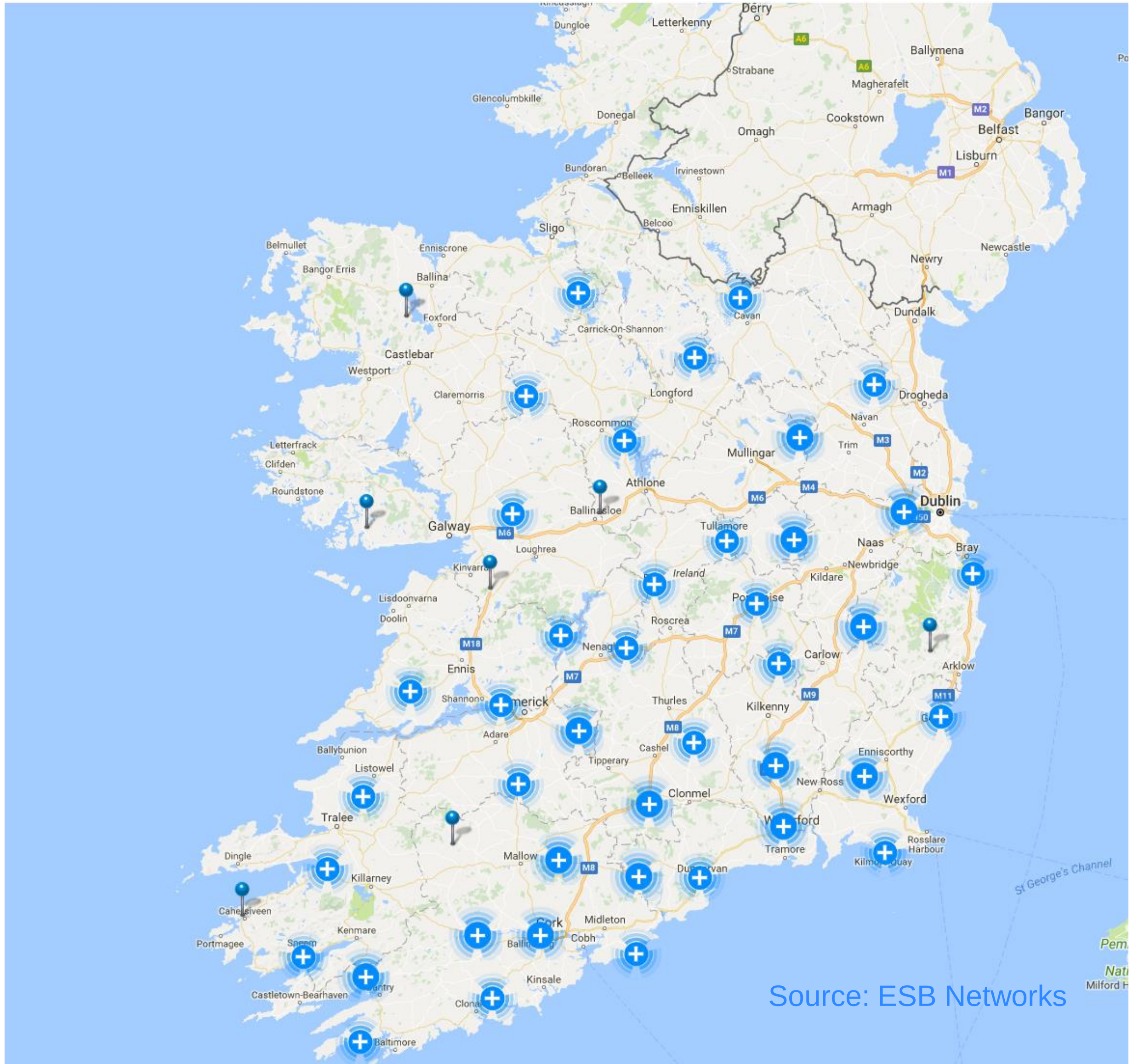
- **Biggest storm** to have reached Ireland from across the Atlantic since records began
- **10th tropical storm** in a row to develop into a hurricane as it crossed the Atlantic – unprecedented in records
- Biggest storm to hit Ireland since 1961
- 39 storm days in a row last winter



Source: Irish Independent

POWER OUTAGE CLUSTERS IN IRELAND AT 16.00, MONDAY, 16TH OCTOBER, 2017

Source: RTE News now



Source: ESB Networks

- Crews have **less time to repair** damage as the storms become more frequent
- The need to reduce outage minutes for customers due to storm damage is driving increased **power network automation**

BIG STORMS CONTINUE

- **18 September, 2018 – Storm Ali**

- “The damage is mainly attributable to fallen trees on overhead lines as a result of the high winds”.

- At the height of the storm, **186,000 customers** were impacted.

- **12 October, 2018 – Storm Callum**

Source: PowerCheck.ie

- **30,000 customers** without power

DRYER CLIMATE

› **Less rain** so droughts and shortages are getting more common

› Exceptionally warm periods and droughts are driving water utilities to increase metering, automation and the use of pumping to **stabilise water supplies**, **increasing digital interfaces**

› **Cascading effects** to power infrastructure as nuclear power plants are being switched off when there is not enough water available to cool them in dry summer months (e.g. France)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Homeowners told to only use dishwashers and washing machines when full as droughts loom after the driest six months in 20 years

- Dry period for UK with some areas having just half their usual level of rainfall,
- Major water provides ask customers to save water to help preserve supplies
- Southern Water pumps river water into major reservoir to help raise levels
- Public asked to use sponge to clean the car and swap baths for short showers

By MARK DUELL FOR MAILONLINE
PUBLISHED: 13:47 BST, 4 May 2017 | **UPDATED:** 13:57 BST, 4 May 2017

Share | 27 shares | 93 View comments

Homeowners have been told to only use their dishwashers and washing machines when they are full as droughts loom in parts of Britain.

The country has faced its driest October to March in 20 years with some areas having just half their usual level of rainfall, prompting a chance of hosepipe bans.

Major water provides such as Affinity are encouraging customers to save water to help preserve supplies and minimise the possibility of summer restrictions.

© PA

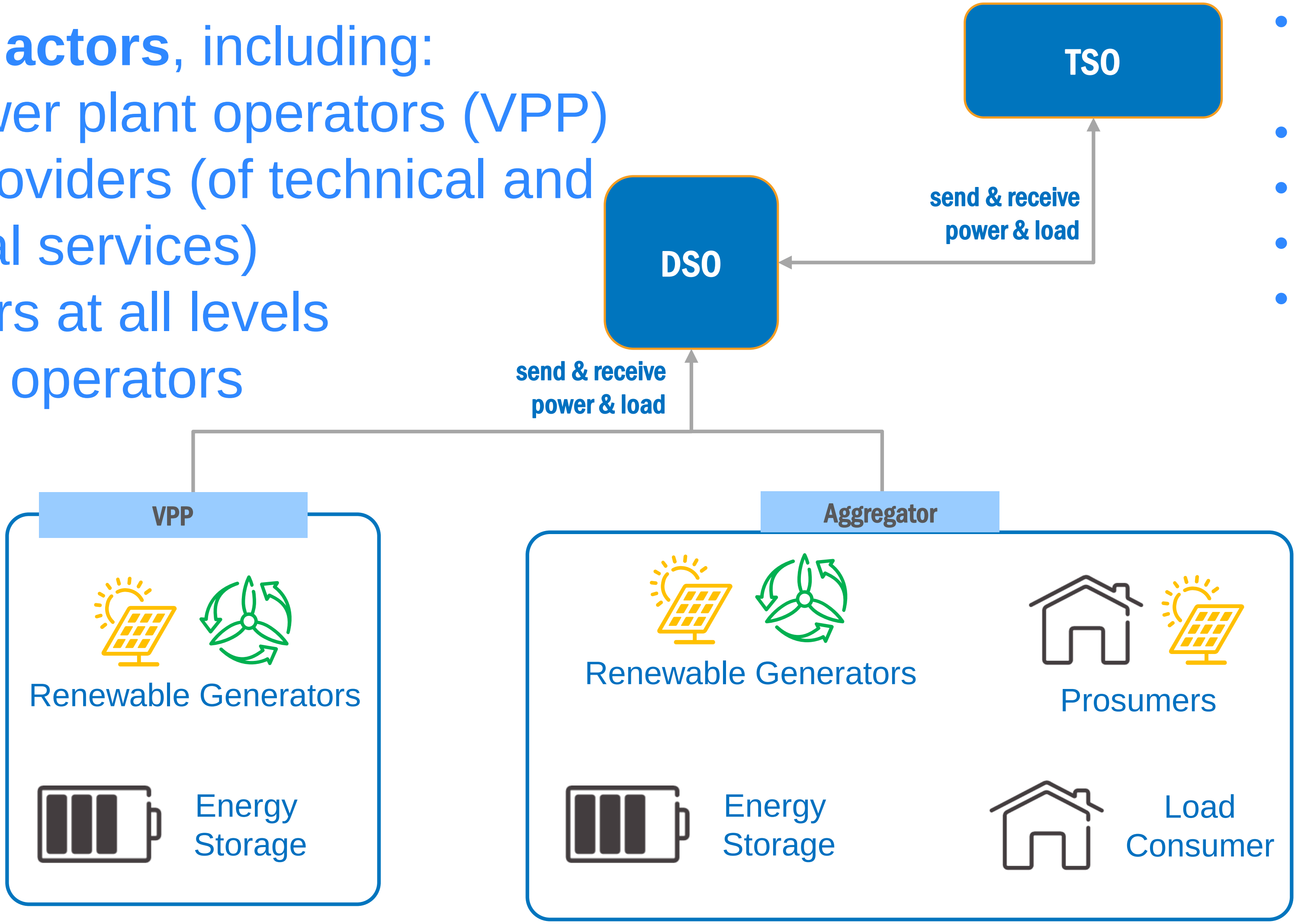
Source: Mail Online

The country has faced its driest October to March in 20 years with some areas having just

POWER GRIDS EVOLVE TO REDUCE CO2 EMISSIONS

New sector actors, including:

- Virtual power plant operators (VPP)
- Service Providers (of technical and commercial services)
- Aggregators at all levels
- Microgrids operators



- **More volatile** renewable energy source generation
- **More** pro-summers
- **More** energy storage
- **More** sector actors
- New **digital interfaces**

- New techniques needed to **stabilise the power supply** at **DSO** and now at **TSO** level too
- New **black-out recovery** techniques needed
- Cascading effects of power outages are **growing**

RESERVE

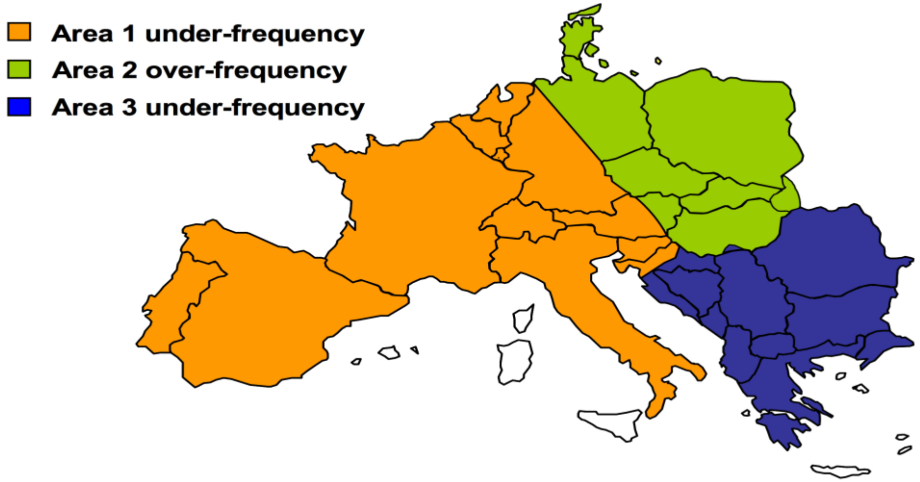
SMART GRID INFRASTRUCTURES FACE INCREASING RISK DUE TO ATTACKS & TO HUMAN ERROR

Ukrainian power grid cyber attack (12/2015)

First known successful cyber attack on power grid!

1. **Compromise of corporate networks** via emails infected with phishing malware;
2. **Seizing SCADA control**, then remotely switching substations off;
3. **Disabling IT infrastructure components**;
4. Destruction of files stored on servers and workstations with the **KillDisk malware**;
5. **Denial-of-service attack on call centres** to deny consumers updating on the blackout.

European blackout (11/2006)



- Accidental cause
- Non fulfilment of the N-1 rule
- Insufficient inter-TSO co-ordination
- Graphic courtesy of ENTSO-E

CHALLENGES OF DIGITIZING THE ENERGY SYSTEM

- Societal challenges driving new energy use cases
- New energy technologies are needed
- Communications can be based on 5G
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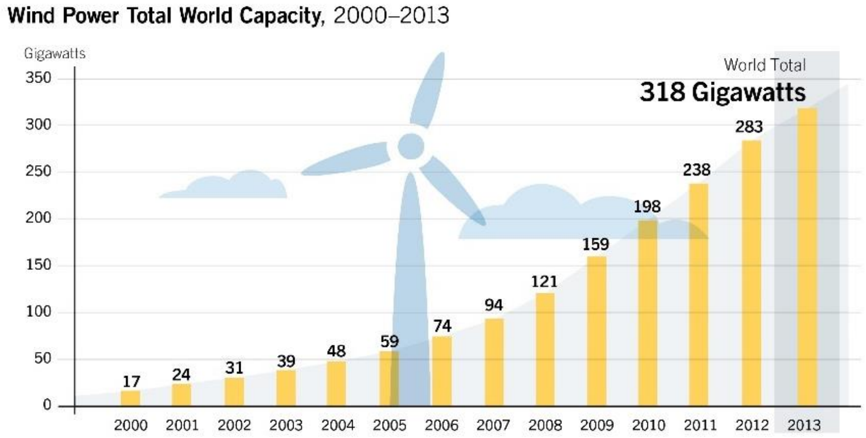
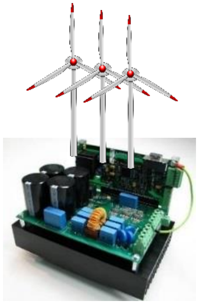
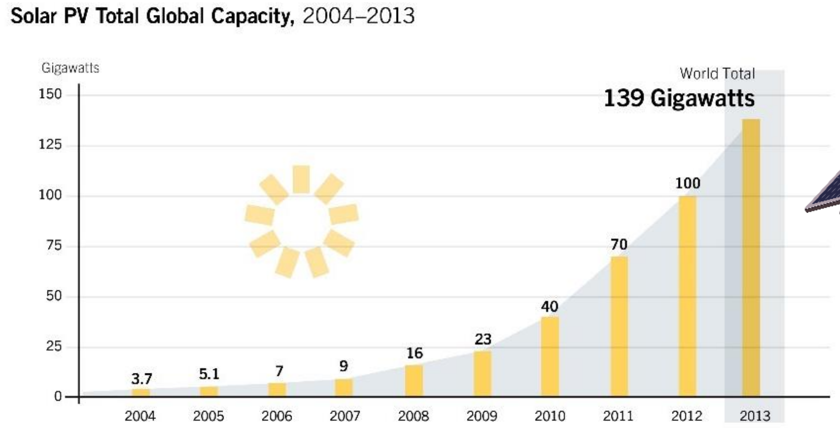
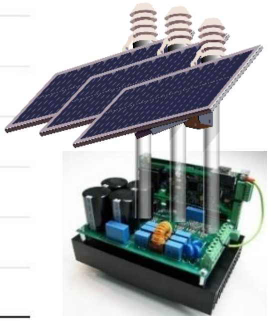
INCREASING RENEWABLE ENERGY = DECREASING SYNCHRONOUS GENERATION



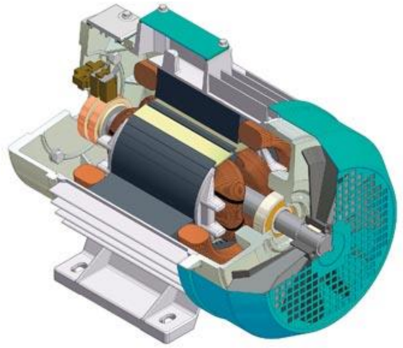






Source: Renewables 2014 Global Status Report

Coal Nuclear



Synchronous Generator, whose inertia stabilises power network frequency

RESERVE

FREQUENCY: ICT SCENARIOS

› **Objective**

– Guarantee dynamic frequency stability of future power electronic AC systems

› **Approach**

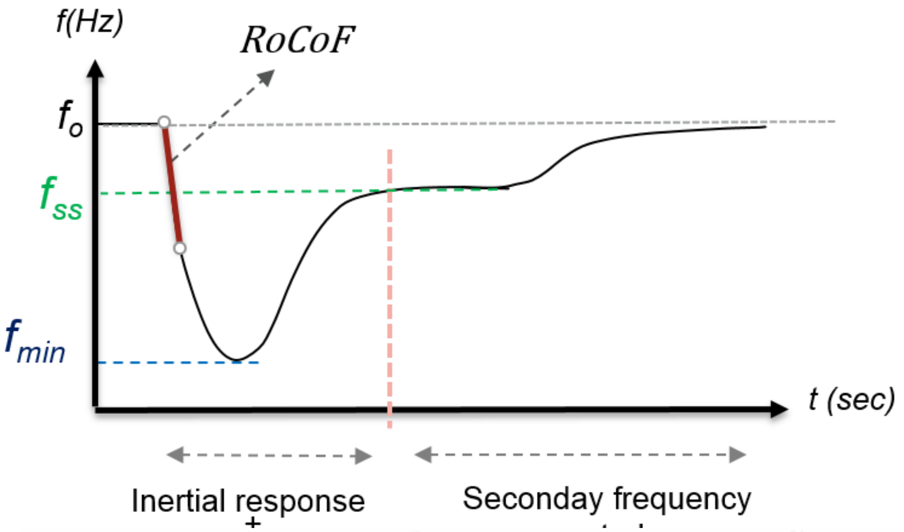
– Define tools and methods for frequency control based on power electronics AC systems and virtual inertia control

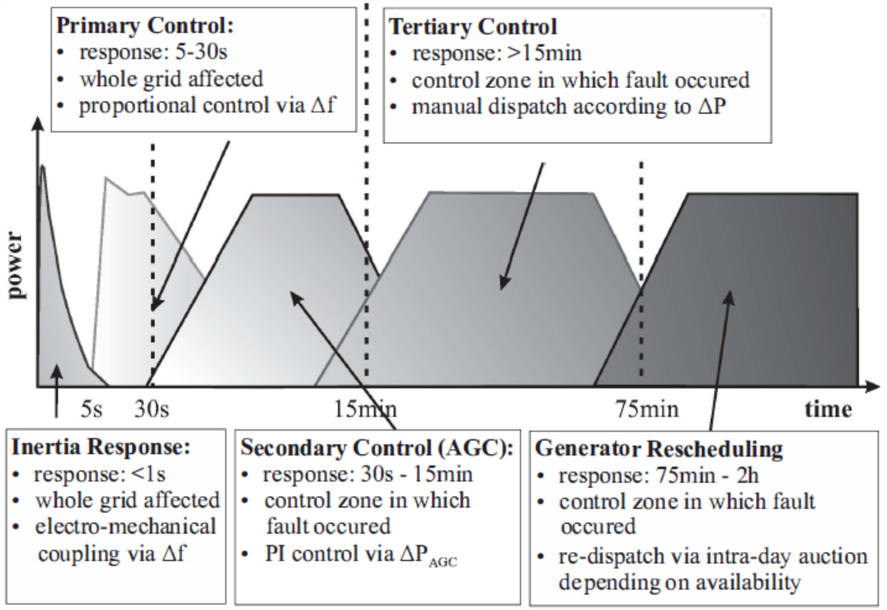
RESERVE Scenarios Frequency Control (10)

Domain	TSO DSO	Time Aspect	Sf_A	Sf_B	Centralised	De-centralised	Distri-buted	Comment
Frequency control	TSO	Inertial Ctrl [RoCoF]	up to 5 seconds	Up to 1 second		☑	☑	No centralised grid control
	TSO	Primary control	Up to 30 seconds	Up to 15 seconds		☑	☑	Expect tighter time limits for the future.
	TSO	Secondary control	Up to 15 min	Much lower**	☑			Centralised grid control only
Frequency control	DSO	Inertial Ctrl [RoCoF]	up to 5 seconds	Up to 1 second		☑	☑	No centralised grid control
	DSO	Primary control	Up to 30 seconds	Up to 15 seconds		☑	☑	Expect tighter time limits for the future.
	DSO	Secondary control	Up to 15 min	Much lower**	☑			Centralised grid ctrl. from TSO level

Note: the time limits are current expectations and requirements, difficult to provide hard limits for 10 years or beyond. Future solution will work better in case of even faster Inertial Control.

**** Much lower than 15 min/Sf_A limit**





RESERVE

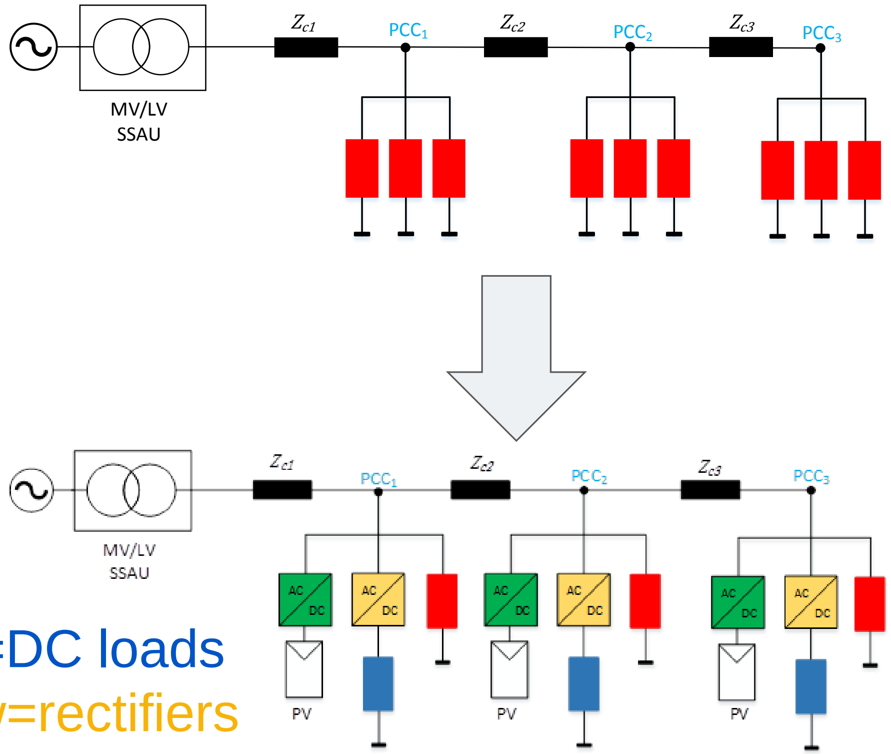
VOLTAGE: ICT SCENARIOS

- **Objective**
  - Guarantee dynamic voltage stability of future power electronic AC systems
- **Approach**
  - Extend tools and methods typical of power electronics DC systems to future power electronic AC systems

RESERVE Scenario Voltage Control (2)

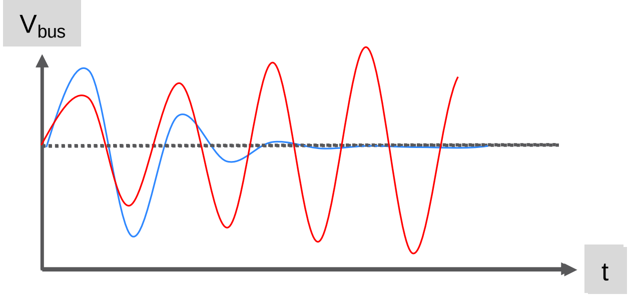
Domain	TSO DSO	Commercial Aggregator	Scenarios	Centralised	De-centralised	Distri-buted	Comment
Voltage control	DSO	No		☑			Traditional: Centralised
	DSO	Yes, optional	Sv_A Dynamic Voltage Stability Monitoring		☑		Future: Decentralised
	DSO	Yes, optional	Sv_B Active Voltage Management		☑		Future: Decentralised

Note that future Voltage Control will use Decentralised network architecture, and it may include *Aggregators* which control parts of a DSO low voltage grid.
Today, the *aggregator* is a commercial entity, it would not usually operate its own *secondary substation automation unit* (S.SAU) where the voltage management of Sv_A is hosted or co-located. This is likely to change in the future.



Blue=DC loads
Yellow=rectifiers
Green=invertors
Red=AC loads

Hybrid AC/DC
Homes included



BLACKOUTS: RECOVERY WITH RENEWABLE ENERGY SOURCES

- Trend towards
  - more locally distributed generation and storage,
  - less large conventional generation,
  - makes traditional methods of blackout recovery more difficult
- ICT is being increasingly applied in Smart Grid solutions, but it is rarely blackout-resilient

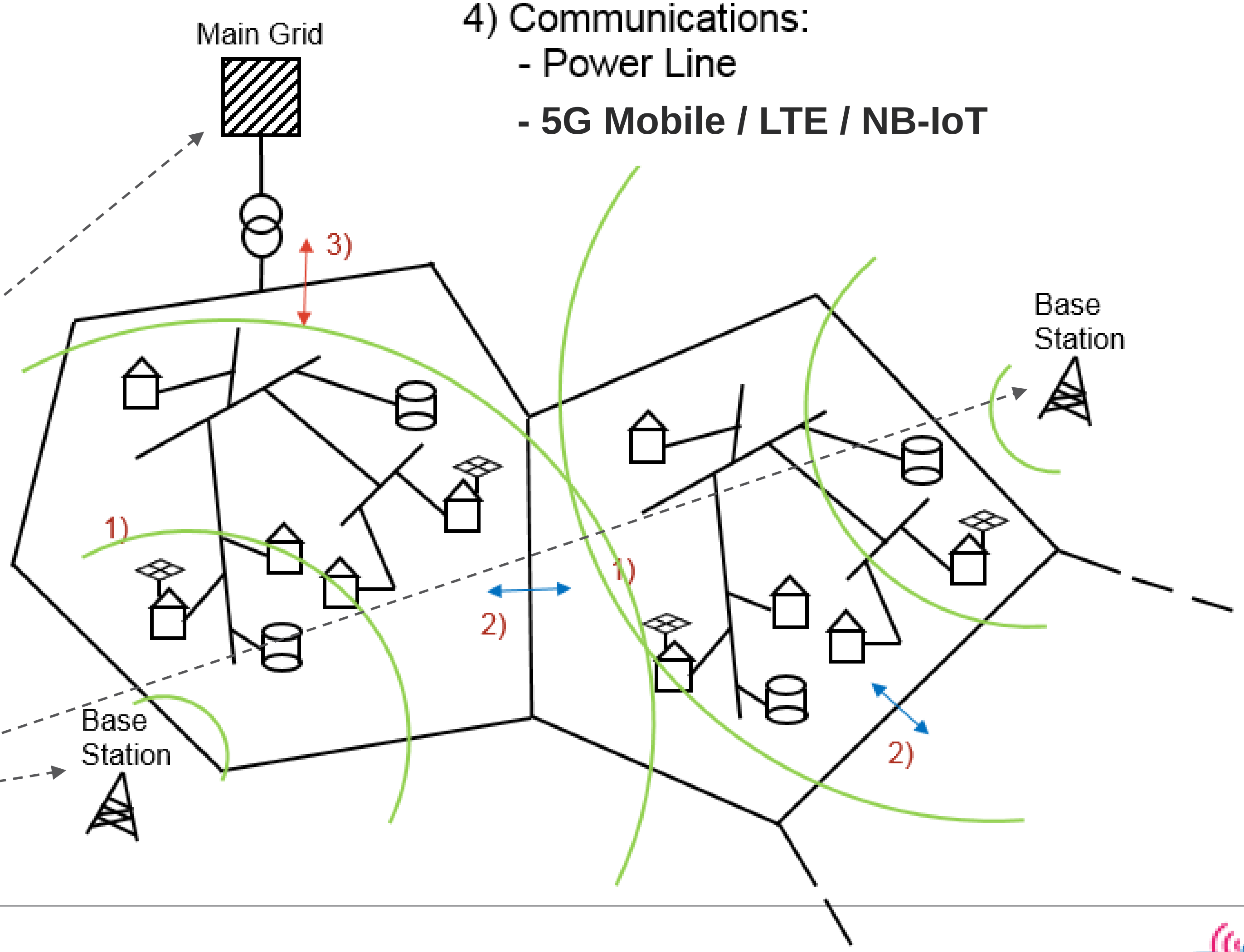
- Objective of the eSafeNet project:
  - Develop **resilient blackout recovery concept** and algorithms fit for future grids
    - consider power grid and ICT aspects
    - solution shall be applicable to real grids and technically realisable
- Enable Microgrid-based Blackout Recovery
  - Optimised, step-wise reconnection of loads and local generation, expanding energised area
  - One microgrid may give power to another

BLACKOUT RECOVERY SCENARIO

- Mobile communication can support 2 microgrids
- Power outage happens in Main grid
- Ericsson Mobile System base stations

Multi-microgrid-based Blackout Restoration Procedure

1) Automatic, autonomous restoration of microgrids
2) Synchronise and connect microgrids together
3) Synchronise to Main Grid
4) Communications:
   - Power Line
   - **5G Mobile / LTE / NB-IoT**



BLACKOUT RECOVERY SCENARIO

› Ericsson Mobile System kicks-in running on power from outside the affected grid or using a secondary power supply from batteries and/or diesel generators

Multi-microgrid-based Blackout Restoration Procedure

1) Automatic, autonomous restoration of microgrids
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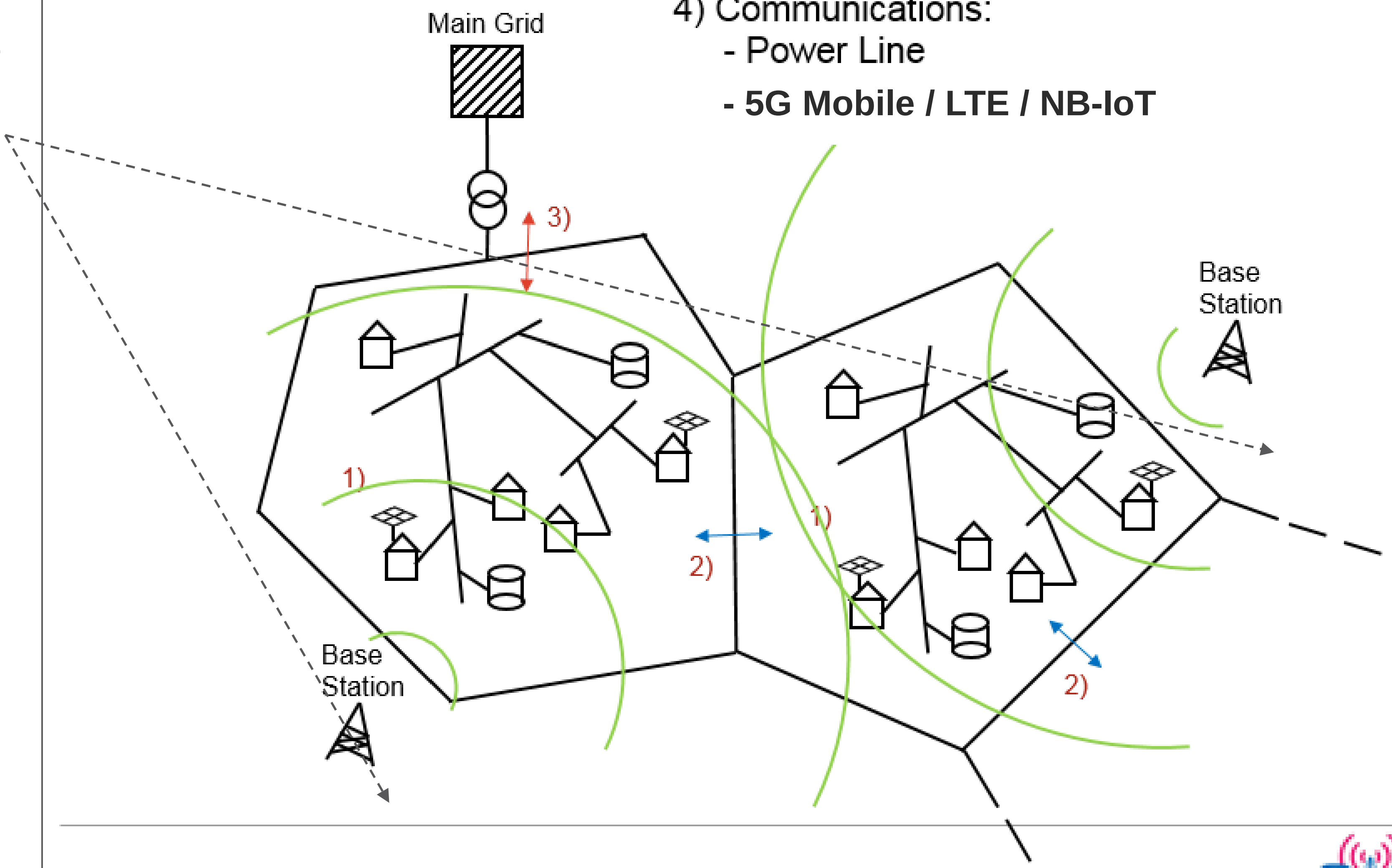


eSAfeNet

SECURITY FOR UTILITIES - CORRELATING THREATS & ATTACKS WITH NEW COUNTERMEASURES

securing critical energy infrastructures

Data Collection
- Meter/Device
- Communication Network
- Utility/DSO network

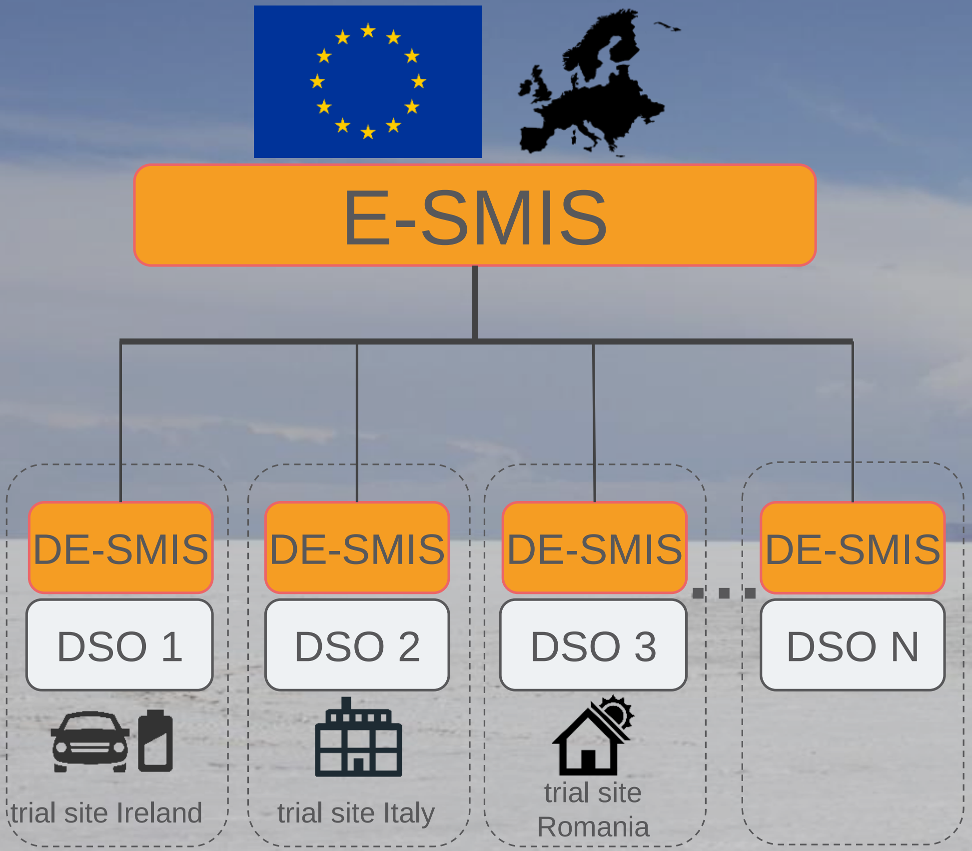
Data Analysis Threat/Attack detection
- DSO level
- Inter-DSO level

Countermeasures Identification
- DSO level

Countermeasures Application
- NORM / SCADA
- Utility/DSO network
- Communication Network

- NORM smart meter data (e.g. voltage, frequency)
- Simple and compound metrics (e.g. packets/second, average latency)
- DSO data and metrics
- DSOSMC/DE-SMIS processes NORM and internal logs data to detect an attack
- E-SMIS processes data from multiple DSOs, intertwined
- Countermeasures identification depending on the identified threat/attack
- E.g. force NORM/PUF re-authentication
- E.g. disconnect or reset a device
- Control function to change configuration (e.g. reroute, block communication)

SUCCESS PAN-EUROPEAN SECURITY MONITORING AND INFORMATION SYSTEM PROTOTYPE



Motivation

- (Distribution) system operators (DSO) connect more than **95% of all customers** to the power system and more than 90% of all renewable generation capacity is installed in distribution systems.
- DSOs have **no possibility to communicate** with each other in case of attacks.
- **Same solutions in hardware and software** are used all over Europe. This enables attacks on multiple systems at the same time.

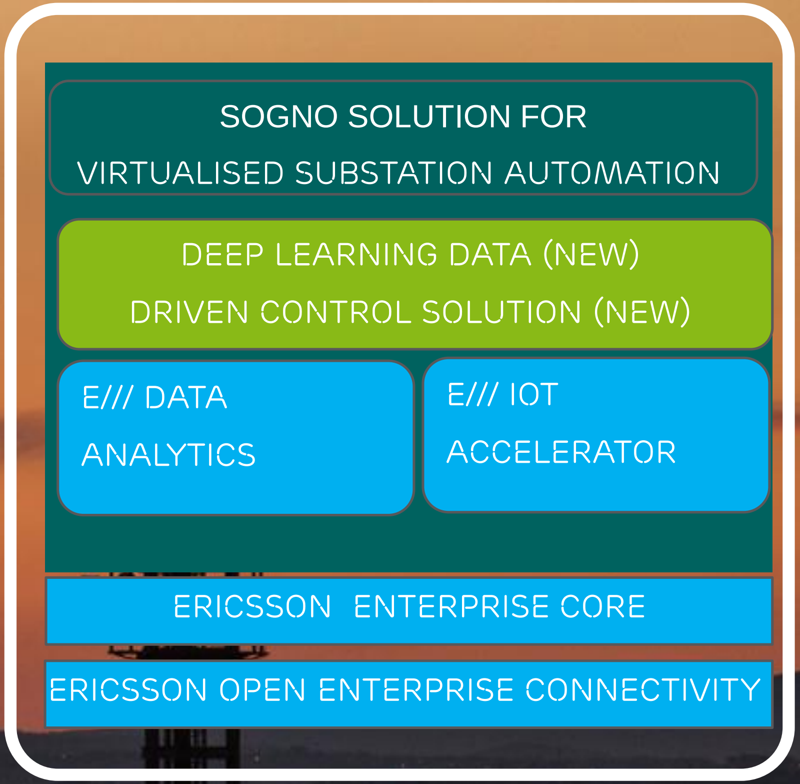
"Small, but similar attacks" on each DSO might not be recognized on a DSO-level, even though the result might affect the whole of Europe

success securing critical energy infrastructures

SOGNO - CLOUD BASED AUTOMATION FOR RESILIENT ENERGY

- New “automation functions” will be matured, integrated and offered as a service over private/public mobile networks (4G and 5G) to utilities

- **Software functions, virtualized and turned into services,** in this project:
  - Fault Location Identification and System Restoration (FLISR = low latency time critical application), (5G needed)
  - State Estimation, (NB-IoT or LTE or 5G – will work with all!)
  - Load Forecasting, (NB-IoT or LTE or 5G)
  - Power Control, (NB-IoT or LTE or 5G)
  - Power Quality Evaluation (NB-IoT or LTE or 5G), and
  - Utility KPI evaluation for QoS evaluation (LTE or 5G needed)



REQUIREMENTS FOR SECURE UTILITY COMMUNICATIONS

- **Commercial Utility networks will require**
  - Very high availability & reliability
  - Secure communications to many new end points
  - Latency at near real-time levels for the most advanced functions
  - Service provider (utility) control of QoS and security
  - Support for highly distributed power network architectures
  - Flexibility to adapt as circumstances change

CHALLENGES OF DIGITIZING THE ENERGY SYSTEM

- **Societal challenges driving new energy use cases**
- **New energy technologies are needed**
- **Communications can be based on 5G**
- **5G Laboratory testing and Field Trials of solutions**

WIRELESS ACCESS GENERATIONS

The foundation of mobile telephony

Mobile telephony for everyone

The foundation of mobile broadband

The future of mobile broadband

The Networked Society

1980 | *1990* | *2000* | *2010* | *2020*

National Systems

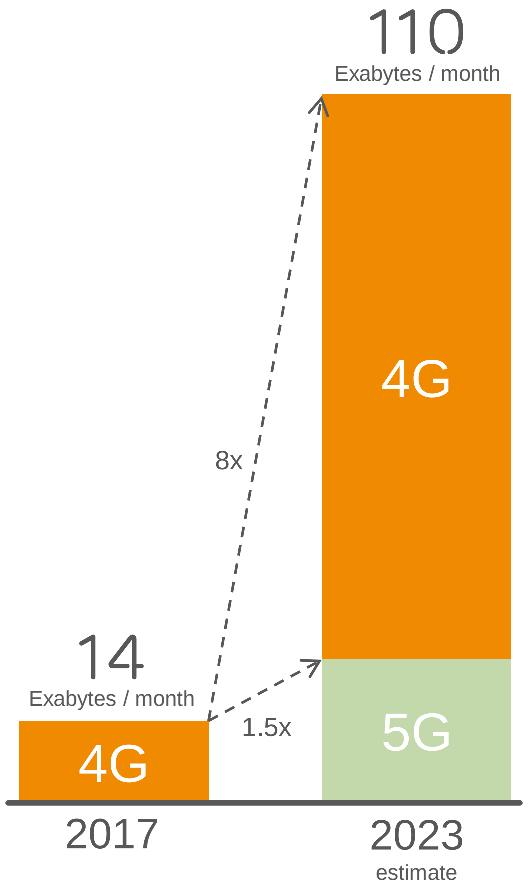
GSM (first EU wide system)

UMTS

LTE

Providing a wireless connectivity platform for the services of the Networked Society

MASSIVE TRAFFIC GROWTH PUTS PRESSURE ON 4G



Global mobile data traffic

8 X

Data traffic growth between 2017 and 2023

1.5 X

more 5G data traffic in 2023 than total mobile data traffic in 2017

Need for 4G investments in capacity and coverage growth to ensure good user experience

4G capacity investments should be 5G-proof

Source: Ericsson Mobility Report
4G traffic figures also include a small proportion of other 3GPP traffic

5G OPEN FOR BUSINESS

Consumer needs drive evolution of mobile broadband content

User behavior changing

Users spend more time on watching and sharing video

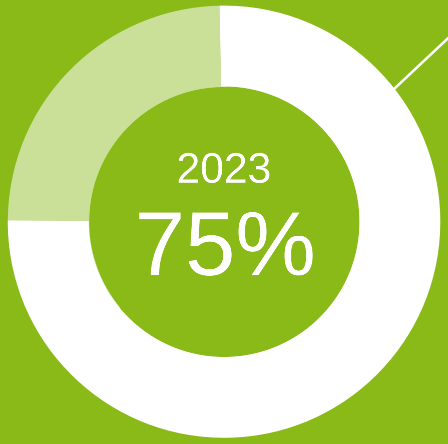
On-line content increasingly video

Embedded in most online content (news, ads, social media, etc)

Emerging immersive media formats and applications

HD/UHD, 360-degree video, AR/VR

Video of total mobile data traffic



Video increasingly dominant

Driving MBB traffic growth

5G IS USE CASE DRIVEN

Massive IoT

- Smart meter
- Tracking
- Fleet management

Critical IoT

- Industrial application & control
- Traffic safety & control
- Remote manufacturing

Enhanced Mobile Broadband (eMBB)

- VR/AR
- 4K/8K UHD
- Smartphones

Fixed Wireless Access (FWA)

- Mobile / Wireless / Fixed
- Enterprise
- Home

What to expect from 5G

Peak Data Rate	1 - 20 Gbps
User Experienced Data Rate	10-100 Mbps
Spectral Efficiency	×1 - ×3
Mobility	350 - 500 km/h
Connection Density	10k – 1M devices / km²
Network Energy Efficiency	×1 - ×100
Area Traffic Capacity	0.1 - 10 Mbps / m²
Availability	99.999% (of time)
Reliability	99.999% (of packets)
Latency	1 - 10 ms
Battery life	10 years*
Security	Strong subscriber authentication, user privacy and network security

*For low power IoT devices

Source: ITU-R, NGMN, 3GPP

5G: ONE NETWORK – MULTIPLE INDUSTRY USE CASES

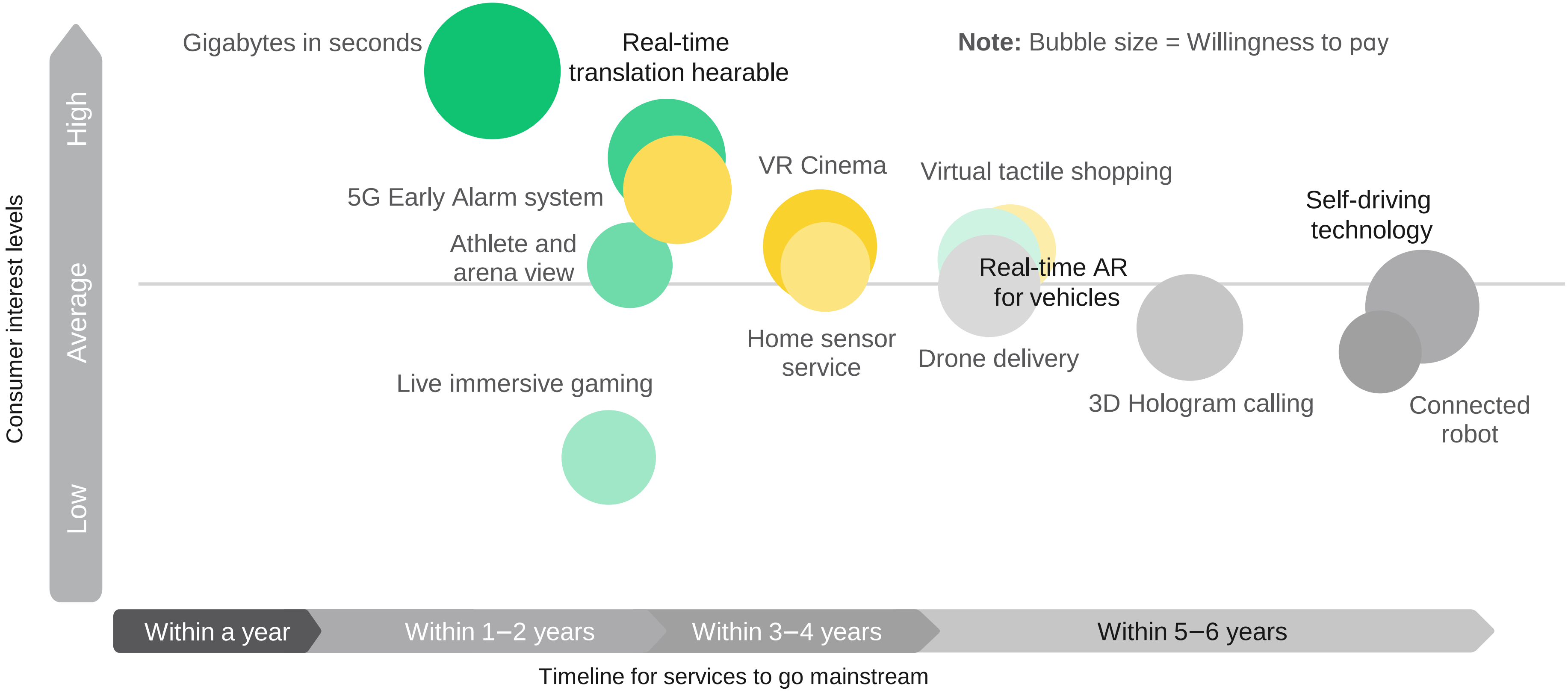
A common network platform with dynamic and secure Network Slices

5G: ONE NETWORK – MULTIPLE INDUSTRY USE CASES

A common network platform with dynamic and secure Network Slices

Give us more with 5G

Consumers predict most 5G services will go mainstream within three to four years of launch



Globally 5G services appeal to 76 percent of smartphone users and 44 percent among them are even willing to pay.

Base: Smartphone users aged 15–65 with interest in 5G services across Argentina, Brazil, China, Egypt, Finland, France, Germany, Indonesia, Ireland, Japan, Mexico, South Korea, the UK and the US

Source: Ericsson ConsumerLab, Towards a 5G Consumer Future, 2018

IT IS ALL ABOUT USE CASE EVOLUTION WITH SUPPORTING TECHNOLOGIES

		On the road to 5G	5G experience
Enhanced mobile broadband	Screens everywhere	New tools	Immersive experience
Automotive	On demand information	Real-time information vehicle to vehicle	Autonomous control
Manufacturing	Process automation	Flow management and remote supervision	Cloud robotics and remote control
Energy & utilities	**Metering and smart grid**	**Resource management and automation**	**Machine intelligence and real-time control**
Healthcare	Connected doctors and patients	Monitoring and medication e-care	Remote operations
Technologies	Multi-standard network Cat-M1/NB-IoT Cloud optimized functions VNF orchestration	Gigabit LTE (TDD, FDD, LAA) Massive MIMO Network slicing Dynamic service orchestration Predictive analytics	5G NR Virtualized RAN Federated network Distributed cloud Real-time machine learning/AI

ENERGY & UTILITIES USE CASE EVOLUTION EXPLAINED

› Dynamic and bidirectional grid
› Smart metering

Current

› Distributed energy resource management
› Distribution automation

On the road to 5G

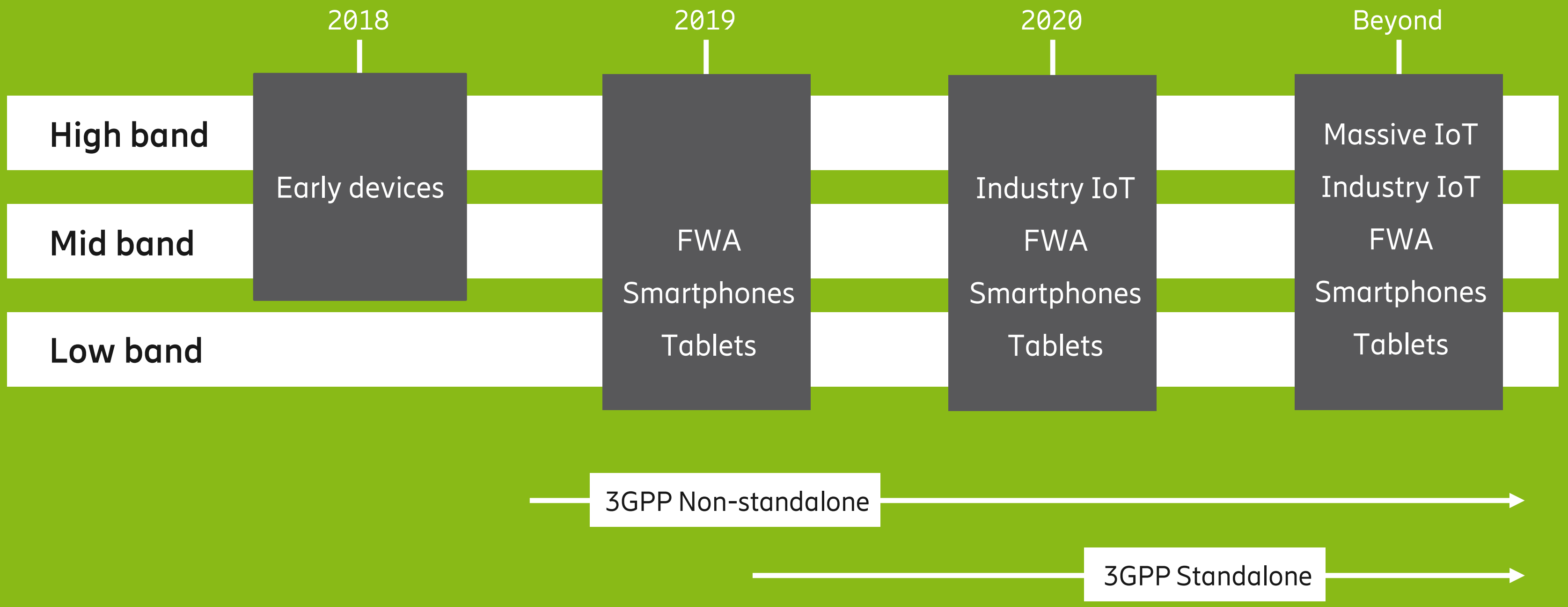
› Control of edge-of-grid generation
› Virtual power plant
› Real time load balancing

5G Experience (2023+)

ENERGY & UTILITIES USE CASE EVOLUTION EXPLAINED

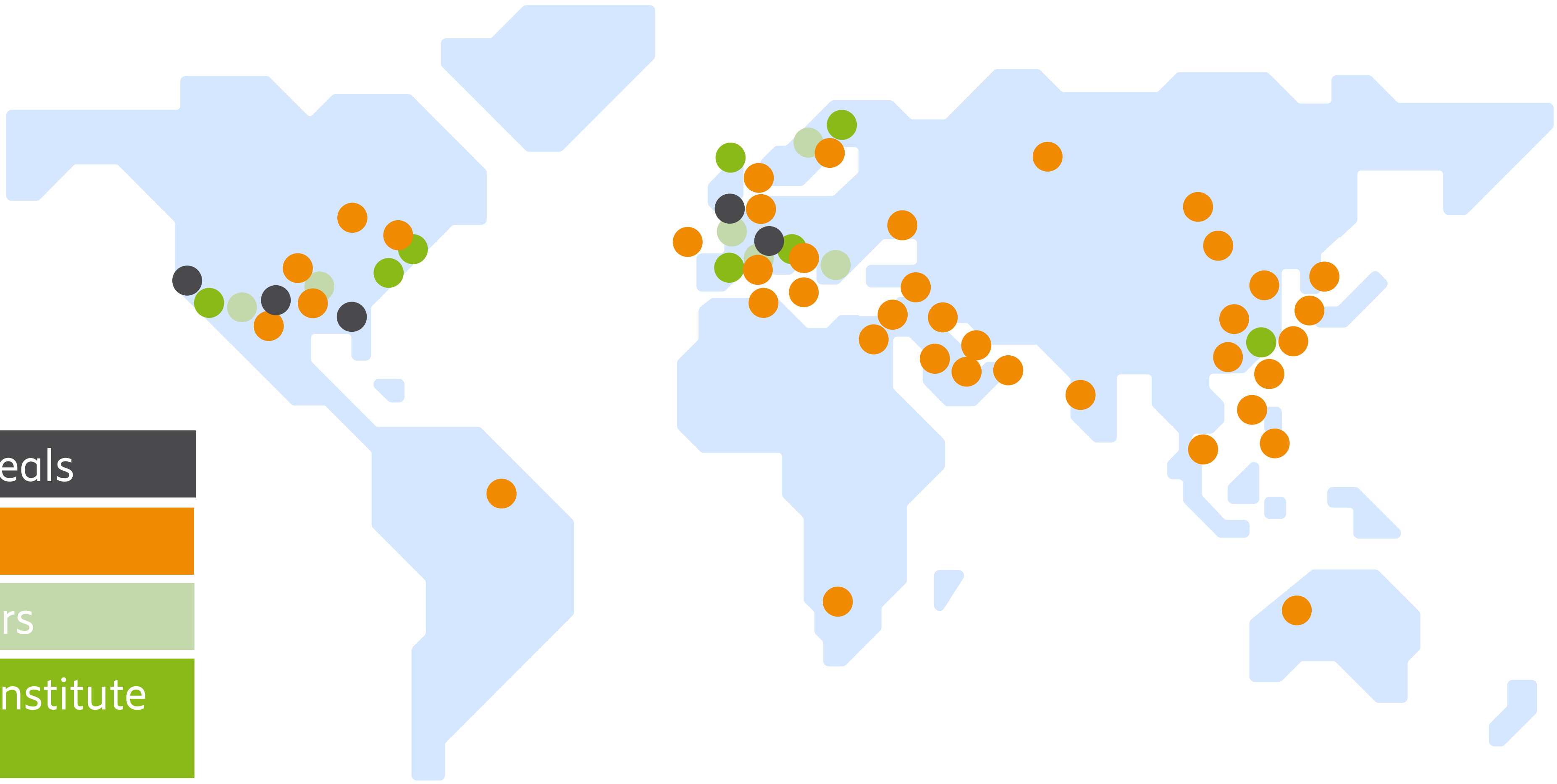
	Current	On the road to 5G	5G Experience (2023+)
TECHNICAL REQUIREMENTS	☑ Coverage ☑ Robust performance	☑ Reduced latency ☑ High throughput	☑ Latency: 8ms ☑ Reliability: 99.999%
TECHNOLOGIES	☑ Multi-standard networks ☑ Cat-M1/NB-IoT ☑ Cloud optimized network functions ☑ VNF orchestration	☑ Gigabit LTE (TDD, FDD, LAA) ☑ Massive MIMO ☑ Network Slicing ☑ Dynamic service orchestration ☑ Predictive analytics	☑ 5G NR ☑ RAN virtualization ☑ Federated network slicing ☑ Distributed Cloud ☑ Real time Machine learning/AI

5G DEVICES AVAILABILITY



FWA: Fixed Wireless Access

ERICSSON HAS THE BIGGEST 5G MOMENTUM



5 announced 5G deals

40 operator MoUs

22 industry partners

45 university and institute collaborations

As of August 2018

OPERATOR PARTNERS

40

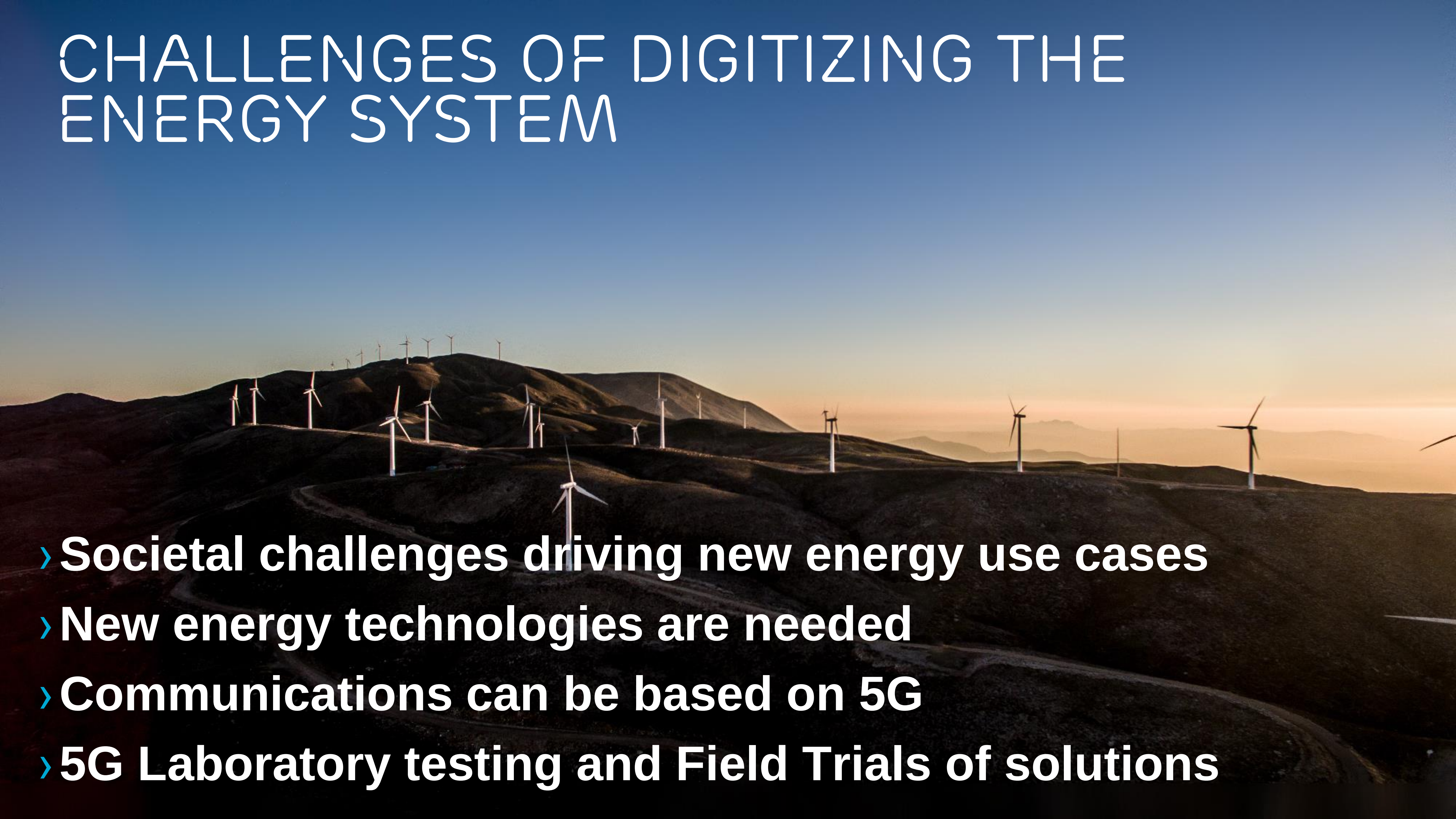
Announced 5G operator agreements

*As of August 2018

REQUIREMENTS AND 5G SOLUTIONS FOR SECURE UTILITY COMMUNICATIONS

- **Commercial Utility network automation and Pan-European monitoring and countermeasures will require**;
- Very high availability & reliability
- Highly secure communications to many new end points
- Latency at near real-time levels for the most advanced functions
- End user control of QoS and security

- **New solutions based on 5G:**
- 5G high availability & reliability
- 5G low latency for the most advanced functions
- 5G security features (e.g GBA)
- Edge processing for low latency and network resilience and survivability
- Network slicing for end user QoS and security control
- SDN for re-configuring networks on the fly for resilience
- 4G, NB-IoT for connectivity



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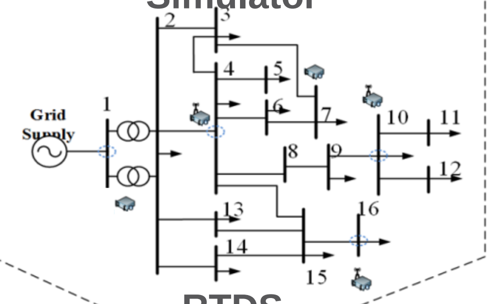
TEST SETUP AT RWTH, GERMANY WITH LIVE 5G MOBILE NETWORK

Power System Simulator



RTDS

Analog Signals

MMS Server

Power network messages

5G Base station

Core Network

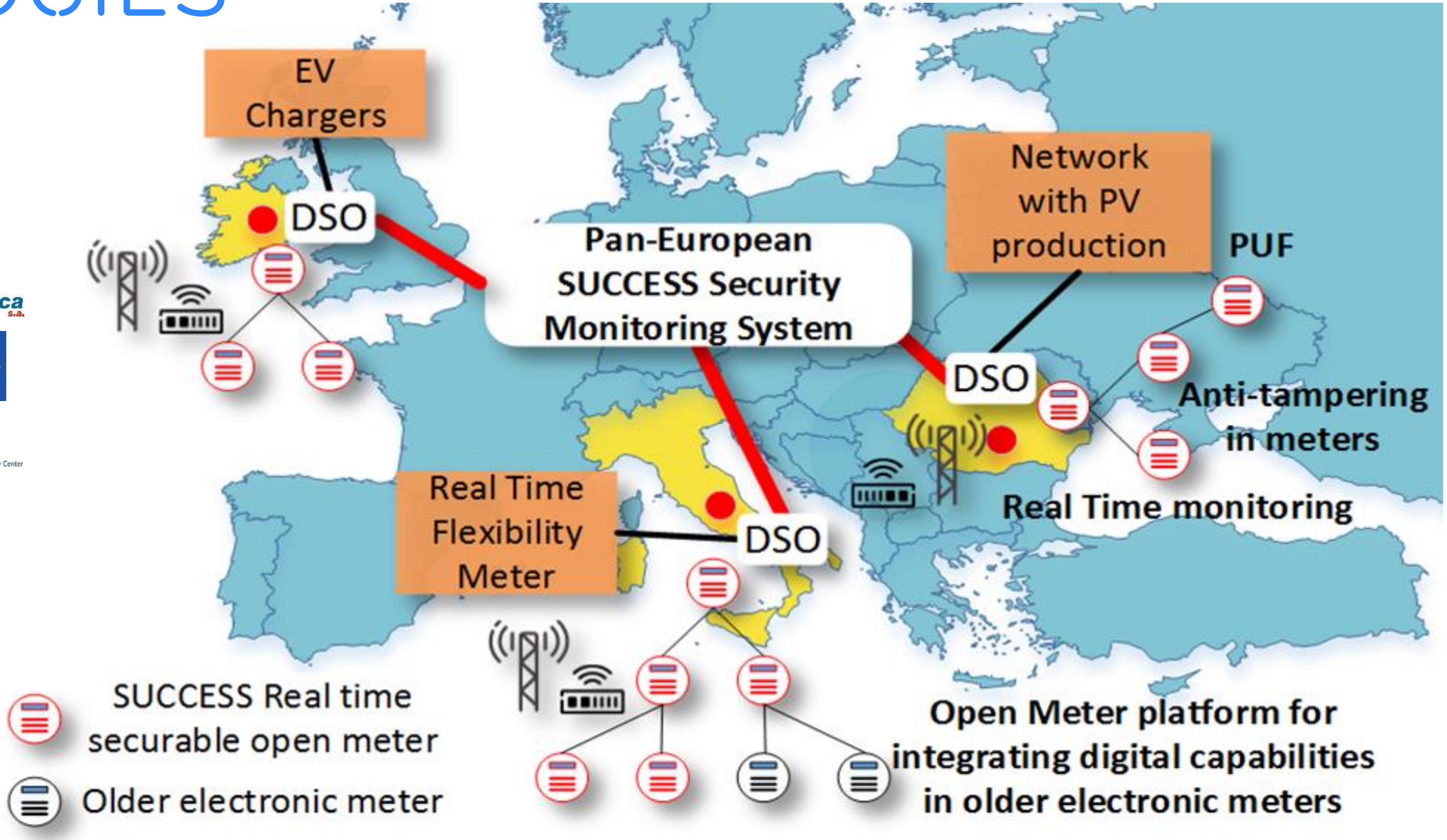
SCADA Control Centre

Power network messages

Communications network Traffic in the Background

RTDS Power Network Simulator

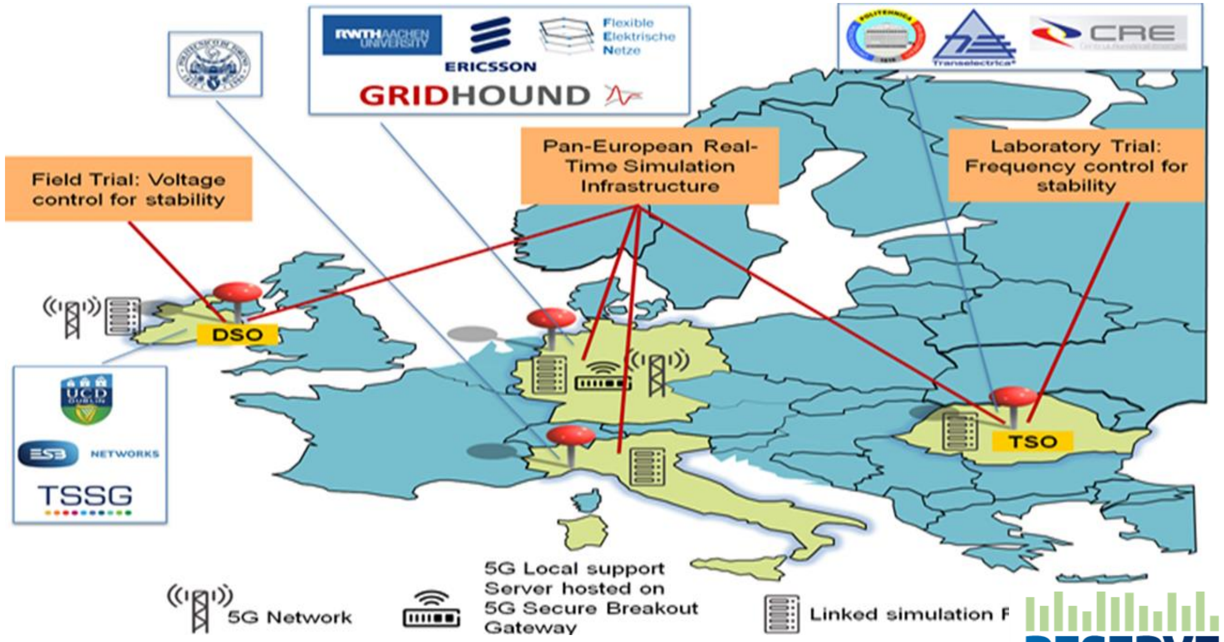
SUCCESS CYBER SECURITY TRIALS & TECHNOLOGIES



securing critical energy infrastructures

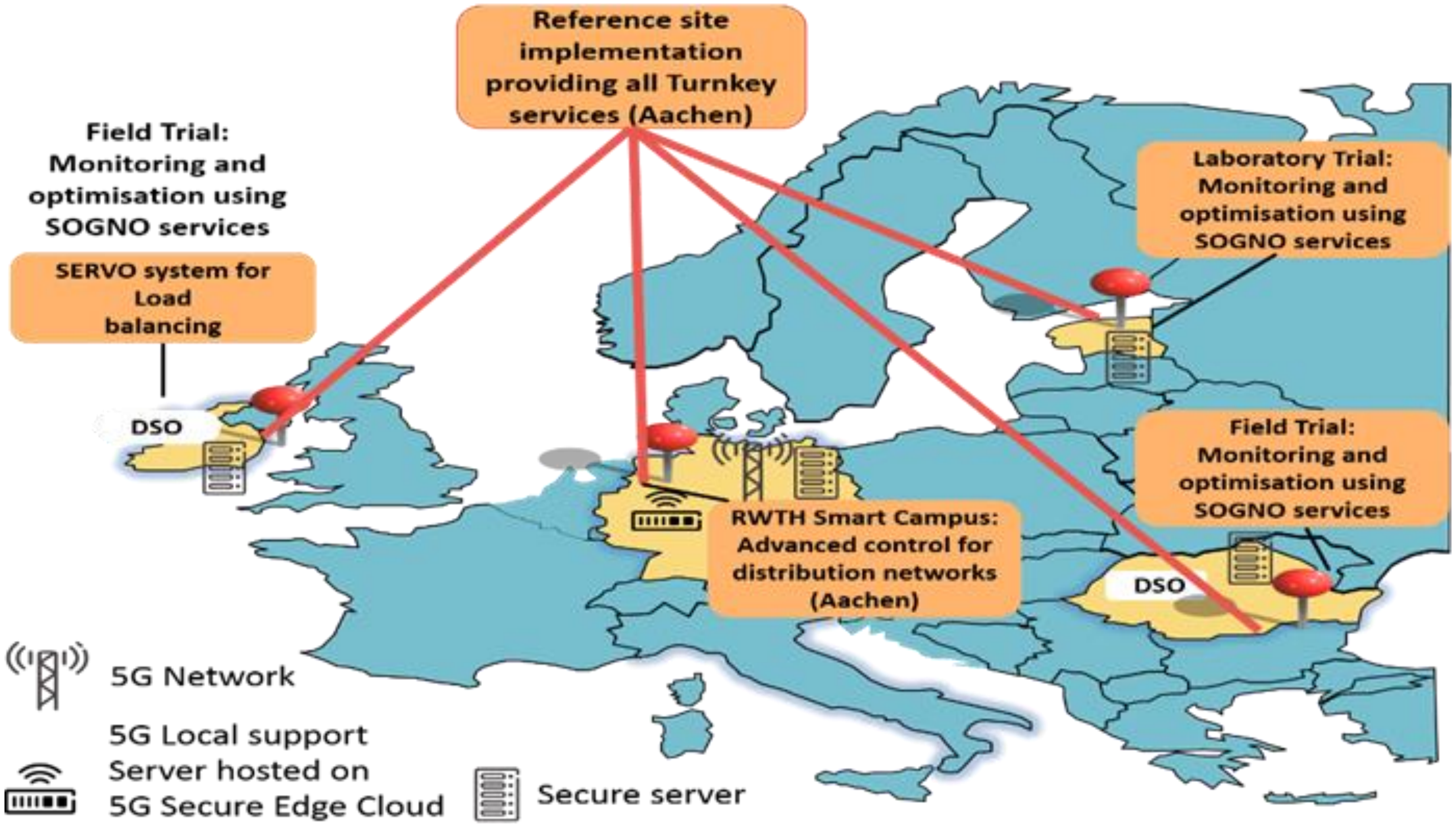
RE-SERVE - UP TO 100% RENEWABLES IN A STABLE ELECTRIC GRID

- Goals
  - New concepts for Voltage and Frequency Control
  - Enabled by 5G ICT & network slicing for real-time
    control applications
  - Pan European Real-Time Simulation Infrastructure
    (connecting labs from Italy, Germany, Ireland, Romania)
  - Harmonized Networks codes development
- Project details
  - Duration: October’16 – September 2018



RESERVE

SOGNO – DISTRIBUTION GRID "AUTOMATION AS A SERVICE" FIELD TRIALS



THE CHALLENGES OF DIGITIZING THE ENERGY SYSTEM

- Changing expectations regarding the role of the energy system
  - Addressing the challenges of climate change and cyber-terrorism as well as the risks of system complexity,
  - Changing priorities and lifestyles of young adults,
  - Rapidly changing business models towards services in society,
  - Increasing interconnections between vertical sectors at the data level to provide new services which is blurring the boundaries between sectors in the Smart City context
  - An increasing reliance of society on reliable communications and power supplies,
- The operation of the energy system is challenged by
  - New security threats and increased cascading effects of attacks,
  - New energy system solutions with increased requirements on ICT for connectivity, and control of energy networks, including many new distributed energy system architectures,
- 5G Concepts and systems will have a big role to play as part of the solutions!

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